



R.C.A. INSTITUTES. INC. *formerly* MARCONI INSTITUTE *Founded 1909*



Technical Lesson 20

SOUND

Not many students realize the importance of sound in connection with the study of radio. Sound vibrations or waves mark the beginning of the radio broadcast program. Sound is employed to actuate the microphone in a way that controls the form of the electro-magnetic wave which is detected by the radio receiver. The receiver, in turn, reconverts the electro-magnetic waves into sound waves. We may rightly say, then, that sound waves play an important part in radio programs at the studio and at the receiving end.

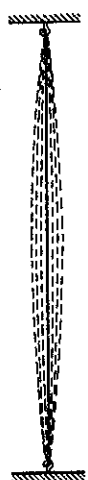


Figure 1

Since the sound waves controlling the broadcast transmitter moulds the current sent to the antenna into a form which, upon being passed through the receiver, is converted again to sound waves which are exactly similar to those occurring at the transmitter, it is important that we study this subject of sound for the reason that it gives us a very concrete idea why certain parts of the transmitter and receiver function.

The word sound is a most comprehensive word,- it applies to anything that is audible. Because sound is going to be employed to vary electrical current it should be clearly realized that we should know just how sound is capable of accomplishing such a result. Sound may be transmitted through liquids, gases, and most of the solids. Although certain sounds carried through the air may be inaudible to the ear, the same sounds may be distinctly heard through a solid or through a liquid. The speed of sound through air is about 1100 feet per second and through a solid, such as steel, about 15 times as fast as through air and, through water, nearly five times as fast as through gas. Sound is produced because the molecules of the sounding body or medium have been caused by some means to oscillate or vibrate.

The tuning fork is the most common method employed to show a body in a state of vibration or oscillation, and how sound is produced by a vibrating body.

A very simple experiment producing both vibration and sound may be performed by stretching a rubber band and plucking it as shown in Figure 1. Upon striking a tuning fork similar results are obtained as shown in Figure 2.



Figure 2

Both the rubber band and the ends of the tuning fork can be seen in motion and the sound produced by this vibrating motion can be distinctly heard. If any vibrating body will cause the sense of hearing to be

excited, denoting sound, the vibratory motion must be transmitted by some material medium, such as air, solids, or liquids. Sound waves will not travel through a vacuum which proves that one of the three mediums mentioned is necessary in order that sound may be sent from one point to another. Furthermore, the transmission of sound waves from a vibrating body may be transmitted through any substance elastic in nature. When sound waves strike substances such as felt, heavy curtains and draperies, the vibrations are damped, or deadened; they tend to prevent the transmission of sound.

To understand how sound is transmitted we must briefly study motion because of the fact that the vibrating body sets the air in motion

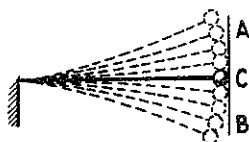


Figure 3

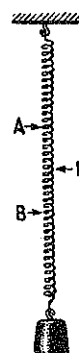


Figure 4

which takes on a definite form. All bodies are composed of minute particles, and each particle of the vibrating body, when set in motion, moves in a forward and backward motion along a definite path. When each particle returns to the same condition at regular recurring intervals, the motion is called periodic. However, if in addition, the particle is being continually reversed in direction such as in the case of a swinging pendulum the motion is then classified as being vibratory.

In the study of sound the vibrations of elastic bodies have to be considered and these are identified as either transverse or longitudinal vibrations. A vibration of transverse nature may be described as vibrations which inscribe a path perpendicular to the direction of the body producing them. For example, if a hat pin is stuck into a block of wood, the head drawn down and released, it will vibrate for a short period of time and the path of the vibrations will be as shown by the dotted lines in Figure 3. Such vibrations are called transverse vibrations and can be both heard and seen.

Longitudinal vibrations are shown in Figure 4 by the use of a coil spring and weight. If positions A, B and P are located on the spring, and the weight is pulled down and released, the weight and the particles of the spring will set up vibrations which are parallel to the length of the spring. The particular turn of wire in the coil at P will vibrate between the positions, A and B, equidistant from P, hence such vibrations are called longitudinal.

A single vibration in sound is usually considered to be the motion of the particle from one extreme position in one direction, such as A, in Figure 4, and a return of the particle to the extreme position B in the reverse direction and then back to A. The time that the particle requires to vibrate from A to B and back to A, that is, making one complete vibration, is termed the period of vibration. Further the distance from P to A or from P to B is called the amplitude of the vibration, and the number of complete vibrations taking place in one second is called the frequency of the vibrations.

When the surface of a body of water is set into vibration as by throwing a stone into a pond, the stone upon striking the water sets the water particles at that point into vibration and adjacent water particles

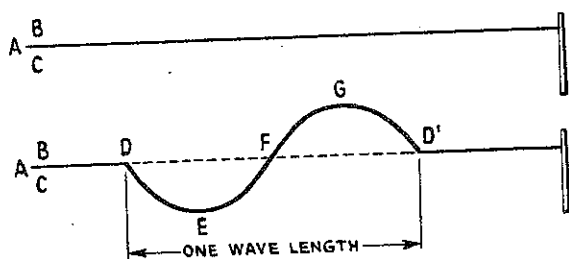


Figure 5

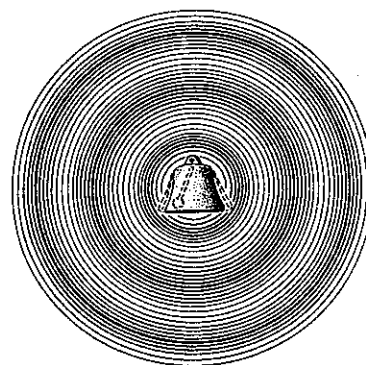


Figure 6

quickly assume a similar motion. One particle after the other takes up the vibration but at a short interval of time after the preceeding one. Considering the surface of water to be a row of adjoining particles the entire row will be set into vibration. At any instant, the particles are all in different phases of vibration hence the result of the series of particles, when in different phases of vibration, is to produce a wave or waves which, like all vibrations, may be transverse or longitudinal.

A transverse wave form can be shown by using a rope, as shown in Figure 5. By giving the rope a quick up motion, from A to B, and then down to C, particles of the rope between D and D' will be seen to be in every phase of vibration. At point D the vibration is starting. At E the vibration is one quarter completed, at F one half, at G three quarters, and at D' one vibration is entirely completed. The wave thus caused has length and is measured from D to D' and is called one wave length.

The bell in Figure 6 is set into vibration when the clapper strikes any portion of the bell. As the bell vibrates the air near the surface of the bell is suddenly forced outward, compressing it. This compressed layer of air at once exerts a pressure on the particles of air next to it, setting them in motion. This pulse or wave continues onward for a considerable distance. The air particles causing it, however, travel

but a very short distance, - only far enough to set the adjacent layer of particles in motion. The outward vibration of the bell, which has caused this disturbance and compression of the air particles, now swings back, causing a partial vacuum. The air particles next to the bell surface now rush in to fill this partial vacuum which causes a similar movement to take place along the compressed portions of the wave and the air particles surge backward in an effort to restore themselves to a state of rest. It will be seen therefore, that on the outward movement of the vibration the air is compressed and the condition due to the returning vibratory movement causes what is known as a rarefied state to exist among the air particles. When these sound waves strike the organs of hearing it produces the sensation of sound.

- (1) The velocity of a wave is equal to the wave length times the frequency,
- (2) or the wave length is equal to the velocity divided by the frequency
- (3) or frequency is equal to the velocity divided by the wave length

Where (Lambda) λ = wave length of sound waves
 V = velocity of sound waves
 and F = frequency of sound vibrations

Then we may write each of the above expressions as follows; giving the basic formula for velocity first:

$$\begin{aligned} (1) \quad V &= \lambda \times F \text{ or } V = \lambda F. \\ (2) \quad \lambda &= V \div F \text{ or } \lambda = V/F. \\ (3) \quad F &= V \div \lambda \text{ or } F = V/\lambda. \end{aligned}$$

Although the above formula is written here to illustrate sound waves, it will be shown later that the same formula is also used for determining the wave length of radio waves.

NOISE

When a crash occurs, such as a head-on collision between two trucks, sound is produced. This sound is classified as noise because the crash creates a non-periodic vibration, or wave motion. Such sounds are generally unpleasant to the ear and some non-periodic vibrations may become even painful to the sense of hearing.

MUSICAL SOUNDS

Music is the result of a rapid series of periodic vibrations and, when such sounds occur or are produced at regular intervals, they are pleasing to the ear and have a soothing effect. The intensity of a sound will depend upon the energy of the vibrating air particles producing the sound wave which strikes the ear.

Some individuals classify the loudness of a sound differently than others; this may be caused by a varying distance or position between the source of the sound and the recipient, or it may be due to a difference in the hearing power of one ear over another. Sound from any sounding body may be intensified, or, made louder by bringing near to it another body, the nature of which will allow it to vibrate at the same period of the sound vibration.

THE PITCH OF A TONE

The pitch of a tone refers to the highness or lowness of the tone. Pitch depends upon the vibrating frequency and the greater the number of vibrations per second the higher will be the pitch of the tone and, as the vibrations decrease per second and become slower, the pitch of the tone will be lower. A piccolo produces a high pitched or high frequency tone, while the base horn produces a low pitched or low frequency tone.



HARMONICS

A simple tone results when a definite pitch is involved producing a single musical sound. When a series of simple tones are combined, in which the vibrating frequencies of each simple tone are represented by whole numbers, then the combined tone is said to be made up of a harmonic series of tones. When tones are in harmony their relative frequencies of vibration may be expressed by whole numbers. Figure 7



Figure 8

In the study of musical sounds the ratio of the frequencies of two simple tones is known as the interval between them and the octave is the most important interval between two simple tones in which one of the tones has twice as many vibrations per second as the other. When a series of notes are struck on the piano, each one higher than the last by one octave, we hear a series of tones which vibrate in harmony.

If a stretched piano string is struck at its center point it will vibrate as a whole just as the rubber band did when you stretched and plucked it at its middle point. A string set into vibration in this fashion shows a form of half wave, and the tone heard from such a string, in vibration as a whole, will be what is called its primary or fundamental vibration or frequency tone. See Figure 7.

If you now place your finger on the center of the string and then strike each half they will be seen to vibrate as shown in Figure 8, and they will maintain this form of vibration when the finger is released. The tone heard will be an octave higher than when vibrating as in Figure 7. When a tone one octave higher is produced by the string vibrating at twice the fundamental frequency, it is said to be vibrating at its second harmonic. If it vibrates three times faster than the fundamental, it is called the third harmonic, etc.

A harmonic is a multiple of another frequency. We can, therefore produce multiples of a fundamental which are second, third, fourth and fifth harmonics, and so on upward.

You will study about harmonics in connection with electro-magnetic waves when the subject of transmitters is taken up. They are calculated the same as harmonics of sound waves. In music they are desirable while in radio they are not always desirable and, when not required, steps are taken to suppress them.

BEAT NOTES

When two tuning forks are set into vibration, the first vibrating at a frequency of, say 200 vibrations per second, and the second vibrating at 201 vibrations per second, they will vibrate together or be in phase once every second and opposite in phase each half second later. The vibrations from such a combination will produce what is called a beat note once each second.

The beat note is recognized by the tone being strengthened when the vibrations of each fork are in unison and, dying away as the vibrations become out of unison or phase, then becoming stronger and stronger until the vibrations are again working together when a full tone is again heard. With the tuning forks in this instance, this strong tone or beat note would be heard every second. Suppose the first fork is vibrating at 200 vibrations per second and the second at 202 vibrations per second. The beat note would then be heard twice every second. This principle of beats is employed in radio receiving and is explained in a later lesson on super-heterodyne receivers.

Let us see now how the sound waves we have been discussing are able to control electric currents. The ordinary telephone you use in your home closely resembles a radio telephone transmitter, or microphone. We will study this ordinary telephone so that we may know how the control of electric current is accomplished.

The telephone transmitter, or microphone, is a device in which sound controls the current. The receiver converts this current flow back to sound. The essential parts of such a device are the transmitter, a conducting line over which the current is guided, and a receiver.

The transmitter, Figure 9, consists of a mouth piece A, a thin mica diaphragm D, and an insulated piece of carbon, E, in the form of a disc which is connected to the button B. "F" shows the fine carbon granules loosely packed between E and G, G being a second insulated carbon disc which, by means of a wire connection, makes contact with the base of the transmitter H.

The receiver, Figure 10, consists of a permanent magnet I, coils J and J, and K, the diaphragm of the receiver.

A steady current is applied to the transmitter and follows the path from battery, "Bat", to H of the transmitter and to the carbon disc G, through the loosely packed carbon granules F, to carbon disc E, thence through the primary winding of an induction coil L, returning to the battery.

From your study of the induction coil you learned that when current of a constant value flows in the primary winding, no current will be induced in the secondary winding, therefore, with a constant current flowing through the granules of the transmitter no current will flow through the receiver magnets. Now allow sound waves to be directed into the mouth piece of the transmitter and the pressure or condensation of the sound wave produced by vibration causes the mica disc D to increase the pressure on the carbon granules, packing them closer together, and when thus compressed they have the peculiar property of permitting an electric current to flow quite readily and with little resistance. But when lying loosely against each other they interpose a very considerable resistance to the flow of current through them thus reducing the amount of current which passes. This increased pressure on the diaphragm then allows a greater current to flow through the granules and through the primary winding of the induction coil "L". Because more current is admitted to the primary winding of the induction coil, the field will become stronger thus inducing a current in the secondary winding.

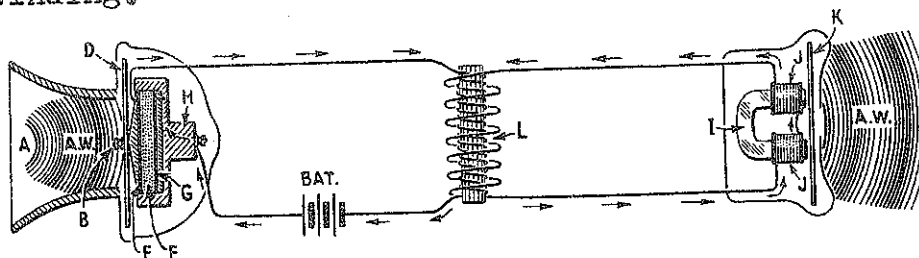


Figure 9

Figure 10

A rarefaction of the sound now takes place which allows the diaphragm D to fall back thereby reducing the pressure on the carbon granules, and this decrease in pressure against the granules allows them to again assume a loosely packed state, thereby decreasing the strength of the current passing through them and also through the primary winding of the induction coil. This results in another change in the value of the induced current in the secondary. These variations in the current strength will cause corresponding changes in the number of lines of force passing through the secondary of the induction coil "L". The induced alternating currents set up will vary in strength as well as in their period of vibration, which varies with the vibrations of the sound wave impinged on the diaphragm "D".

These varying alternating currents produce changes in the magnetic field of the receiver magnet I. The consequent changes in field strength of the receiver magnet causes the receiver disc "K" to be alternately attracted and repelled. Attracted and repelled in this

fashion, the disc K reproduces the original vibrations of the transmitter diaphragm and therefore reproduces the sounds similar to the sounds directed toward the transmitter. Thus it is seen how sound waves are employed to vary an electric current and, then by use of the receiver, reconverted back to sound waves.

The transmitter is, in fact, a sort of valve, much like the valve on a steam line, capable of opening up to permit a full flow of current or closing either gradually or suddenly and reducing the current through it. The transmitter will operate on very feeble sound vibrations and, of course, the current changes are controlled by the intensity of these vibrations.

The form of sound receiver most generally used for radio reception consists of two separate receivers mounted on a head band which allows them to fit comfortably to the ears. The loud speaker is a sound producing device used in radio with a horn or other radiating structure so proportioned and designed that a loud sound is produced which can be easily heard at some distant point from the receiver. The receiver of Figure 10 remains silent so long as a steady current is passing through the magnets.

EXAMINATION - LESSON 20

1. Through what mediums may sound be transmitted?
2. Explain how sound travels.
3. How does sound vary the current in a telephone circuit?
4. Is sound a factor to be considered in radio?
5. Explain how a beat note is produced.
6. What formula is used for determining the wave length of a sound wave?
7. What is the meaning of the word, "Amplitude"?
8. What is meant by the "second harmonic"?
9. What is the meaning of the word, "frequency"?
10. Does sound travel faster through air than through steel?